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SOUTHERN PINE BEETLE INFESTATION GROWTH AND DECLINE - 1977

by

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INTRODUCTION

Managing outbreaks of the southern pine beetle (SPB), Dendroctonus frontalis Zimmerman, is dependent upon a thorough understanding of the dynamics of infestation growth and decline. SPB pest management cannot be an arbitrary, random, or subjective assortment of suppression or tree protection treatments. Rather, effective SPB management is linked to the development of an operational system which monitors pest, host, and climatic conditions and inputs this information to the decision maker (Waters, 1973).

Recent investigations by Hedden (1978), Ku et al. (1977), and Lorio and Bennett (1974) have increased available knowledge about relationships between SPB occurrence and forest stand conditions. This information can be a valuable tool for land managers to avoid infestations through stand manipulation. Linked with this stand information, however, must be the ability to predict SPB activity once it has occurred in a stand, and provide the land manager with biological and economic criteria for decision-making.

Hedden and Billings (1978) investigated factors in east Texas related to SPB spot growth and inactivity. They found number of infested trees, pine and total basal area per acre positively correlated to spot growth. Based on this correlation, Hedden (1977) developed a hazard rating system to predict potential spot growth.

The present evaluation seeks to explore the following areas:

(1) In relation to work done by Hedden and Billings (1978) in east Texas, investigate in other geographic areas and at different

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levels of SPB activity the variables associated with SPB infestation growth and decline.

(2) Evaluate the effectiveness of Hedden's SPB hazard rating system for predicting continued spot growth.

PROCEDURES

Twenty-four SPB infestations were selected for evaluation in Texas (4), Louisiana (18), and Mississippi (2). Evaluation began in March 1977 and ended in September 1977. All infestations were evaluated from their initial detection to spot inactivity.

Data collection. Methods of data collection were based on those used by Hedden and Billings (1978).

At the initial visit to an infestation, a circular .1 ac plot was established as near to spot origin as possible. Tree species and d.b.h. were recorded from all trees (greater than 3 inches d.b.h.) within the plot. At the actively infested part of the spot, all infested pines were tagged and d.b.h. recorded. In addition, brood stage present (egg, larva, pupa, callow adult, or parent adult) was determined by removing a section of the bark at breast height of all infested trees. The spots were revisited every 4 weeks until beetles were no longer present. At each revisit, any newly infested pines were tagged and d.b.h. recorded.

Variables under consideration in the evaluation were:

1. PBAA - actively infested pine basal area at initial visit.
2. ATO - number of infested trees at initial visit.
3. ATK - additionally attacked pines at each revisit.
4. TBAC - total basal area per acre at spot origin.
5. PBAC - pine basal area per acre at spot origin.
6. ADBH - average d.b.h. of infested trees.
7. PCPA - percent of infested trees at initial visit containing attacking adults. Attacking adults are described as those beetles initiating attack.

When a spot went inactive, a circular .1 acre plot was established at the area of last activity. Diameter at breast height for all trees greater than 3 inches was recorded from within the plot.

The resulting data were subjected to two correlation analyses; the first grouped all 24 spots together, and the second grouped only those six spots which experienced additional tree mortality. Both analyses held additional trees killed (ATK) as the dependent variable, and total basal area per acre (TBAC), pine basal area per acre (PBAC), average diameter at breast height of infested trees (ADBH), percent of infested trees with attacking adults (PCPA), and pine basal area infested (PBAA) as the independent variables.

A discriminant analysis of the variables was performed to describe the relative importance of the variables in their ability to distinguish between spots with additional tree mortality and those without.

RESULTS AND DISCUSSION

Of the 24 spots evaluated, 18 (or 75 percent) were inactive by the second visit (within 30 days) and without any additional tree mortality. The remaining six spots were inactive by the third visit (within 60 days). Additional tree mortality after the first visit occurred in six spots and averaged six trees per spot.

A summary of the mean values observed for the variables included in the evaluation is presented in Table 1. Evaluated spots averaged 38.2 infested trees per spot at initial visit (Range 4 - 139). Of the six spots in which additional tree mortality occurred, four had 30 or more infested trees at initial visit. Of the 18 spots in which additional tree mortality did not occur, seven had 30 or more infested trees at initial visit. Hedden and Billings (1978) report that, without exception, additional trees were killed after the first visit in all spots which contained more than 30 infested trees.

Spot variables, such as total and pine basal area per acre at spot origin (TBAC and PBAC, respectively), average d.b.h. (ADBH) of infested trees, or number of infested trees at initial visit (ATO) did not significantly differ between those spots in which additional tree mortality occurred and those in which it did not. Hedden and Billings (1978) reported positive correlations between spot growth and initial number of active trees, pine and total basal area, and pine d.b.h. The present evaluation did not find these correlations. This may have been due to the small sample size (n = 6) of spots in which additional mortality occurred, or that additional tree mortality, when it occurred, was negligible (averaging only six trees per spot).

One variable of particular interest in the evaluation is that of the presence of attacking adults in the infestation. This variable is thought to be important as it relates to pheromone producing

Table 1. Means and standard deviations of the observed variables for SPB spots evaluated in Louisiana, Mississippi, and Texas during 1977.

(a) All 24 cases

Variable	Mean	Standard deviation
Additional trees killed (ATK)	1.5	3.0
Total basal area per acre (TBAC)	111.9	42.5
Pine basal area per acre (PBAC)	92.0	40.6
Average d.b.h. (ADBH)	11.9	4.3
Percent parent adult (PCPA)	31.7	28.0
Pine basal area active (PBAA)	28.9	38.0
Number of infested trees present at initial visit (ATO)	38.2	41.0

Note: The mean and standard deviation of each variable is based on 24 cases with the exception of PCPA, which is based on 22 cases.

(b) Cases with ATK = 0

Variable	Mean	Standard deviation
Additional trees killed (ATK)	0.0	0.0
Total basal area per acre (TBAC)	109.4	48.2
Pine basal area per acre (PBAC)	92.5	45.4
Average DBH (ADBH)	11.9	4.5
Percent parent adult (PCPA)	30.8	31.0
Pine basal area active (PBAA)	29.6	40.8
Number of infested trees present at initial visit (ATO)	41.0	46.3

Note: Each variable has 18 cases with the exception of PCPA, which has 17 cases.

(c) Cases with ATK Positive

Variable	Mean	Standard deviation
Additional trees killed (ATK)	6.0	3.0
Total basal area per acre (TBAC)	119.4	17.6
Pine basal area per acre (PBAC)	90.7	23.8
Average d.b.h. (ADBH)	12.0	4.1
Percent parent adult (PCPA)	34.6	16.3
Pine basal area active (PBAA)	26.7	31.2
Number of infested trees present at initial visit (ATO)	29.7	18.1

Note: Each variable has 6 cases with the exception of PCPA, which has 5 cases.

beetles attracting other beetles to the infestation, hence, contributing to spot expansion. Hedden and Billings (1978) observed that spots destined to go inactive without additional tree mortality were often distinguished on the first visit by the absence of trees with fresh attacks. In the present evaluation, the importance of brood stage present was initially analyzed by describing the percent of infested trees in the spot with fresh attacks. The variable, however, was not found to be correlated with positive additional tree mortality (ATK). A subsequent analysis was performed by characterizing the fresh attack variable (PCPA) with a 1 for those cases where percent attacking adult is greater than zero, and zero if PCPA is zero. A test of the hypothesis for difference of the means between those spots with positive ATK and those with ATK zero yields a t-statistic of 1.38 in testing that the groups have equal means. This value is not significant, but comparing its magnitude with those for the other variables (Table 2), it is apparent that this approach yields the strongest of variables in distinguishing the groups from each other. For the 24 evaluated spots, brood stage information was collected from 22 spots. Of the 22 spots, 17 had pheromone sources present (Range = 0 percent to 90 percent of infested trees with fresh attacks). As indicated in Table 1, the average percent of infested trees at initial visit with fresh attacks is 31.7 percent. It had been expected that spots with this distribution of brood stage would have experienced additional tree mortality. This did not occur.

Hedden and Billings (1978) reported that stand basal area can act in conjunction with pheromone source presence in determining success of spot expansion. They observed that as more trees come under attack simultaneously, stand basal area becomes less important as a factor in spot growth. Conversely, in small spots with few pheromone sources, distance between trees is an important factor (Hedden and Billings 1978), (Johnson and Coster 1978).

In the present evaluation, presence of fresh attacks in an infestation has a correlation coefficient with positive ATK of .2620. This value is not statistically significant, but the correlation is higher than any other correlation involving ATK (Table 3).

Being interested in the relative importance of all the variables in their ability to distinguish between spots with positive ATK and those with zero ATK, a discriminant analysis was performed. Though it has already been shown that none of the variables individually can distinguish between the groups, a discriminant analysis can be performed under the assumption that some of the t-statistics would have produced significant results had the sample size been larger.

Table 2. Dividing the 24 evaluated SPB spots into two groups -- one containing the cases where ATK is zero, the other containing the cases where ATK is positive, the following are the values of the t-statistic in the test of hypothesis that the two groups have equal means:

Variable	t-Value	Significance Probability
TBAC	.49	(.628)
PBAC	- .09	(.929)
ADBH	.05	(.962)
PCPA	.26	(.798)
PBAA	- .16	(.874)
ATO	- .58	(.569)

Note: None of these t-values is significant at the .05 level as indicated by the fact that none of the significance probabilities is less than .05.

Table 3. Analysis of the correlation of ATK (additional trees killed) with the remaining spot variables.

(a) Spots with positive ATK

VARIABLE	CORRELATION WITH ATK
TBAC[1/]	- .5559
PBAC[2/]	.1680
ADBH[3/]	- .5539
PBAA[4/]	- .5253
ATO[5/]	- .2984
PCPA[6/]	- .1870

Note: None of the correlations were found to be significant at the 5 percent level.

(b) All 24 spots

VARIABLE	CORRELATION WITH ATK
TBAC[1/]	- .0414
PBAC[2/]	.0047
ADBH[3/]	- .1059
PBAA[4/]	.0299
ATO[5/]	- .1368
PCPA[6/]	- .1248

Note: None of the correlations were found to be significant at the 5 percent level.

1/ Total basal area per acre at spot origin.

2/ Pine basal area per acre at spot origin.

3/ Average d.b.h. of infested trees.

4/ Pine basal area actively infested.

5/ Number of infested trees present at initial visit.

6/ Percent of infested trees with attacking adults.

Results of the analysis using all the variables (including PCPA redefined as 1 for any fresh attacks present and 0 for fresh attack absence) are weighted in importance by their coefficients as follows:

PBAC	-1.99383
TBAC	1.86717
PCPA	.61011
PBAA	- .54692
ADBH	.21151
ATO	- .16551

The above six variables were used to predict the occurrence of positive additional tree mortality. This resulted in 77.8 percent of the observed cases with ATK = 0 being classified correctly and 66.7 percent of the cases with positive ATK being classified correctly.

Hedden (1977) used observations in east Texas to develop a hazard rating system to evaluate SPB spot growth potential (Fig. 1). Spots selected for study in the present evaluation were grouped according to Hedden's rating system (Fig. 2). None of the evaluated spots ranked as having a high potential for spot growth. Six would have ranked as having medium-high potential, but only one of the six actually experienced additional tree mortality (three additionally killed trees). In each of these six cases, large numbers of infested trees present at initial visit (average = 101) resulted in the spots being classified as having a medium high potential for spot growth. Pine basal area per acre in these spots averaged 79 square feet per acre (Range - 45 sq ft/ac to 118 sq ft/ac) and percent of infested trees with fresh attacks averaged 28 percent (Range = 0% - 49%).

Eighteen of the 24 evaluated spots are classified by Hedden's system as having medium low or low potential. Considering the lack of substantial additional tree mortality in any of the spots, all should have been classed as medium-low or low spot growth potential. The variable most likely to affect the system in order to correctly classify all spots in medium-low or low spot growth potential should be presence of fresh attacks. This variable should reflect population aggressiveness (Hedden and Billings 1978). In the present evaluation, however, the PCPA variable does not help refine the system.

The value of a spot growth hazard rating system is apparent from the results of the evaluation. Many SPB spots do not require immediate treatment to avoid continued volume loss. Control efforts should be concentrated on those spots which are classed as having high spot growth potential.

Variable	Variable Limits	Rank
No. of active trees	> 40	3
	20 - 40	2
	> 20	1
Pine basal area/acre (ft^2)	> 130	2
	≥ 130	1

Rank Values	Potential for Future Spot Growth
5	High
4	Medium high
3	Medium low
2	Low

Fig. 1. Variable and rank values developed by Hedden (1977) for evaluating the potential for future SPB spot growth.

Potential for future spot growth	Hedden's Rank	All evaluated spots n = 24	Spots with additional tree mortality n = 6	Spots without additional tree mortality n = 18
High	5			
Medium-high	4	25% (6)	17% (1)	28% (5)
Medium-low	3	25% (6)	50% (3)	17% (3)
Low	2	50% (12)	33% (2)	55% (10)

Fig. 2. Percentage of evaluated SPB spots that fall in each of Hedden's hazard rating classes.

SUMMARY

1. Additional tree mortality in 24 evaluated spots was not significantly correlated to the expected spot variables, number of infested trees at initial visit, pine or total basal area per acre at spot origin, or percent of infested trees with fresh attacks. This finding differs from that reported by Hedden and Billings (1978). Additional tree mortality, however, may not have been significant enough to allow correlations to become evident.

2. The evaluation has illustrated that all SPB infestations do not expand in size. Of the evaluated spots ranging in size from four to 139 infested trees at the initial visit, only six spots continued to have additional tree mortality and it averaged only six trees per spot. Hedden's SPB spot growth hazard rating correctly classed 75 percent of the spots using number of infested trees and pine basal area per acre. Classifying spots in this manner can help set priorities for spot treatment. Refinement of Hedden's system may be based on some measure of population aggressiveness not evident in this evaluation.

3. Though Hedden's SPB spot growth hazard rating is not a perfect predictive tool, it could be used by forest managers to help set priorities for spot treatment. Too often, SPB spots are removed or treated without regard for spot growth potential. This results in unnecessary destruction of natural control agents, such as competing insects, predators, parasites, and poor use of manpower and equipment.

4. Evaluation of SPB control tactics should always be accompanied by spot growth evaluations or similar population measurements. This will provide information on SPB population potential.

5. State insect and disease specialists should be encouraged to implement SPB spot growth evaluations as an integral part of Federal-State cooperative SPB control projects. This will provide information on volume protected through the control efforts.

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